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For: NONAQUEOUS ELECTROLYTE SECONDARY BATTERY	VERIFIED TRANSLATION OF PRIORITY DOCUMENT

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Sir:

I declare that I can read and speak both the English and Japanese languages, and that I have translated, fully and accurately, the following Japanese application(s) for which priority is claimed:

Copies of my English translation(s) of the above priority application(s) are attached hereto.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or document or any registration resulting therefrom.

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[Title of the Invention] NONAQUEOUS ELECTROLYTE SECONDARY BATTERY

[Scope of Claim for a Patent]

[Claim 1] A nonaqueous electrolyte secondary battery in which at least a disk and a safety valve are arranged on one end side of a cylindrical outer packaging can holding an electrode element therein,

the disk has a central hole,

the safety valve has a projecting portion projecting toward the electrode element at the central portion of the safety valve, and

the projecting portion is connected to a lead of the electrode element through the central hole of the disk,

characterized in that the disk has a linear thin portion.

[Claim 2] The nonaqueous electrolyte secondary battery according to claim 1, characterized in that the thin portion is almost along a circle centering on a symmetrical point of the central hole.

[Detailed Description of the Patent]

[0001]

[Technical Field Pertinent to the Invention]

The present invention relates to a nonaqueous electrolyte secondary battery.

[0002]

[Prior art]

In recent years, portable information devices such as lap-top computers and wordprocessors, AV devices such as camera integrated video tape recorders and liquid crystal television sets, and mobile communication devices such as portable telephones are remarkably developed. For batteries used as power supplies, secondary batteries having small sizes, light weights, and high energy densities are demanded. Until now, aqueous-solution-based secondary batteries such as a lead battery, a nickel-cadmium battery, and a nickel-hydrogen battery are used. These aqueous-solution-based secondary batteries sufficiently satisfy the demands related to light weights and high energy densities.

[0003]

Recently, as clean batteries having high energy densities, an aqueous electorolyte secondary battery attracts considerable attention and is greatly expected.

A conventional nonaqueous electrolyte secondary battery will be described below with reference to FIGS. 4 to 5.

FIG. 4 is a sectional view showing a conventional nonaqueous electrolyte secondary battery (e.g., disclosed in Japanese laid-open patent publication No. 8-315798).

[0004]

FIG. 4A is a sectional view of a conventional nonaqueous

electrolyte secondary battery. In the nonaqueous electrolyte secondary battery, an electrode element 2 is held in a cylindrical bottomed outer packaging can 1, a nonaqueous electrolytic solution (not shown) is injected into the outer packaging can 1, and the nonaqueous electrolytic solution soaks in the electrode element 2.

[0005]

The electrode element 2 is constituted such that a film-like positive electrode and a film-like negative electrode are laminated through a film-like separator, and the laminated films are wrapped around, e.g., a cylindrical core in the form of a coil.

[0006]

On the both sides of the electrode element 2, insulation plates are arranged, and free ends of the leads 9 and 10 of the electrode element 2 are led to the outside of the insulating plates. The free end of the negative electrode lead 10 is welded on the bottom surface of the outer packaging can 1 serving as an electrode terminal leading portion.

[0007]

A lid 7, a PTC element 3, and a safety valve 6 are caulked on one end side of the outer packaging can 1 through a gasket 8 to seal one end of the outer packaging can 1. In this manner, the lid 7, the PTC element 3, and the safety valve 6 are electrically connected to each other.

[0008]

At the central portion of the safety valve 6, a projecting portion 6a projecting toward the electrode element 2 is formed. The projecting portion 6a is welded on a sub-disk 4 through a central hole 11c of a disk 11. In this manner, the projecting portion 6a is electrically connected to the sub-disk 4.

[0009]

The disk 11 is fixed to the inner side of the safety valve 6 through a disk holder 12.

Here, the shape of the disk 11 will be described. FIG. 4B is a plan view of a disk used in a conventional nonaqueous electrolyte secondary battery.

[0010]

Referring to FIG. 4B, an outer edge portion 11a is a belt-shaped plate which partially constitutes the disk 11 and has a circular shape at the outside of the plate. The outer edge portion 11a itself is fixed to the gasket 8 to support the disk 11 as a whole.

[0011]

A recessed portion 11b partially constitutes the disk 11. The shape of the recessed portion 11b is a flat plate and is connected to the edge portion 11a.

The disk 11 has a central hole 11c. The central hole 11c is a circular hole centering the symmetrical point of the

disk 11.

A peripheral hole 11d is an almost rectangular hole having a semicircular portion on the central hole 11c side, and the central axis of the peripheral hole 11d is in the radial direction.

[0012]

The sub-disk 4 shown in FIG. 4A has a thin-disk shape, and is welded on the electrode element 2 of the disk 11 at the center of the disk 11.

A positive electrode lead 9 is welded on the electrode element 2 of the sub-disk 4. In this manner, the sub-disk 4 and the positive electrode lead 9 are electrically connected to each other.

[0013]

An operation of a safety valve used in a conventional nonaqueous electrolyte secondary battery will be described below with reference to FIG. 5. In this case, the safety valve has two mechanisms, i.e., a current cut-off mechanism and a cleavage mechanism.

Before the current cut-off mechanism and the cleavage mechanism are described, a normal state of the safety valve will be described. FIG. 2A is a sectional view showing a manner of the safety valve 6 in the normal state in the conventional nonaqueous electrolyte secondary battery.

[0014]

In FIG. 2A, although the sub-disk 4 closes the central hole 11c of the disk 11, the diameter of the sub-disk 4 is small. For this reason, the hole formed near the outer periphery of the disk 11 is not closed by the sub-disk 4. Since the peripheral hole 11d of the disk 11 is not closed as described above, a gas existing in the battery can pass through the disk 11. In contrast to this, since the safety valve 6 has no hole, the gas existing in the battery cannot be discharged outside, and an airtight state is kept.

[0015]

An operation in the current cut-off mechanism of the safety valve will be described below. FIG. 5B is a sectional view showing an action of the safety valve in a current cut-off state in the conventional nonaqueous electrolyte secondary battery.

[0016]

When gas is generated in the outer packaging can 1 on account of some causes, pressure therein increases. At this time the generated gas passes through the peripheral hole 11d and applies pressure on the inside surface of the safety valve. As a result the safety valve is deformed to the outside.

[0017]

Due to the deformation of the safety valve 6, in the welded portion between the projecting portion 6 of the safety valve 6 and the sub-disk 4, part of the sub-disk 4 that exists in the

surroundings of the welded portion is ripped off by a shearing force. Because of the projecting portion 6a and the sub-disk 4 parting from each other in this manner an electrical connection between the positive electrode lead 9 and the lid 7 is cut off.

[0018]

An operation in the cleavage mechanism of the safety valve will be described below. FIG. 2C is a sectional view showing an action of the safety valve in a cleavage state in the conventional nonaqueous electrolyte secondary battery.

When a pressure in the outer packaging can 1 is higher than the pressure in the current cut-off state, the safety valve 6 itself is cleaved. In this manner, when the safety valve 6 is cleaved, a gas generated in the battery passes through the peripheral hole 11d of the disk 11, passes through a cleaved portion 6b of the safety valve 6, and passes through a ventilation hole 7a of the lid 7 to be discharged outside.

[0019]

[Problems that this invention is to solve]

In this case, the generated gas can easily pass through the cleaved portion 6b of the safety valve 6. However, in the disk 11, the gas passes through only the peripheral hole 11d, and the gas cannot easily pass.

[0020]

As a solving means for the problems, an increase of the opening area of the peripheral hole 11d can be considered.

However, when the opening area is increased, the mechanical strength of the disk 11 itself cannot be easily assured. In order to assure the mechanical strength, the thickness of the disk 11 may be increased. However, when the thickness is increased, the capacity of the battery must be reduced. For this reason, it is actually difficult to increase the opening area of the peripheral hole 11d.

[0021]

As a result, when a gas is generated in the outer packaging can 1, a problem that the generated gas cannot be discharged outside within a short time by a conventional disk occurs.

[0022]

The present invention has been made in consideration of the above problems, and has as its object to provide a nonaqueous electrolyte secondary battery which can discharge a gas within a short time at the time of a safety valve being cloven.

[0023]

[Means for Solving the Problems]

A nonaqueous electrolyte secondary battery according to the present invention is a nonaqueous electrolyte secondary battery in which a safety valve is arranged on one end side of a cylindrical outer packaging can holding an electrode element therein, the disk has a central hole, the safety valve has a

projecting portion projecting toward the electrode element at the central portion of the safety valve, and the projecting portion is connected to a lead of the electrode element through the central hole of the disk, wherein the disk has a linear thin portion.

[0024]

The nonaqueous electrolyte secondary battery of the present invention is a nonaqueous electrolyte secondary battery having the above configuration in which the thin portion is almost along a circle centering on a symmetrical point of the central hole.

[0025]

According to the nonaqueous electrolyte secondary battery of the present invention, since the disk has a linear thin portion, a passage area for a gas in a cleavage state of the safety valve increases.

[0026]

[Mode for carrying out the Invention]

An embodiment of the present invention according to a nonaqueous electrolyte secondary battery will be described below with reference to FIGS. 1 to 3.

FIG. 1A is a sectional view showing the embodiment of the present invention with respect to the nonaqueous electrolyte secondary battery. This embodiment is obtained by applying the present invention to a nonaqueous electrolyte secondary battery

comprising a material in which lithium can be doped or undoped as a positive electrode and (or) a cathode electrode, and a nonaqueous electrolytic solution. However, the present invention is not limited to this embodiment and the example in FIG. 1A.

[0027]

In this embodiment, an electrode element 2 is held in a cylindrical bottomed outer packaging can 1 consisting of iron and plated with nickel (Ni), and a nonaqueous electrolytic solution (not shown) is injected into the outer packaging can 1, and the nonaqueous electrolytic solution soaks in the electrode element 2.

The outer packaging can 1 is not limited to the cylindrical can. In addition to the cylindrical battery, a prismatically cylindrical battery may be used.

[0028]

The electrode element 2 is constituted such that a film-like positive electrode and a film-like negative electrode are laminated through a film-like separator, and the laminated films are wrapped around, e.g., a circularly cylindrical core in the form of a coil.

[0029]

The positive electrode and the negative electrode of the electrode element 2 are formed such that a positive electrode active material and a negative electrode active material are

coated on both the surfaces of a belt-shaped current collecting foil consisting of an aluminum (Al) foil and a copper (Cu) foil.

[0030]

One end of a positive electrode lead 9 consisting of Al and one end of a negative electrode lead 10 consisting of Ni are welded from opposite end portions of the current collecting foils of the positive electrode and the negative electrode. As shown in FIG. 1, the positive electrode lead 9 is led outside the electrode element 2 from the central portion of the electrode element 2, and the negative electrode lead 10 is led from the outer periphery of the electrode element 2.

[0031]

The electrode element 2 is inserted into the outer packaging can 1 such that the leading side of the negative electrode lead 10 faces the bottom side of the outer packaging can 1.

Insulating thin plates are arranged on the both sides of the electrode element 2, and the free ends of the leads 9 and 10 of the electrode element 2 are led outside the insulating thin plates. The free end of the negative electrode lead 10 is welded on the bottom surface of the outer packaging can 1 serving as, e.g., an electrode terminal leading portion.

[0032]

In the electrode element 2, as the positive electrode active material of the positive electrode, a material in which,

e.g., Li can be undoped and re-doped, a complex oxide expressed by an active material Li_xMO_2 (M is transition metal selected from more than one kind of Co, Ni, and Mn, $0.4 \leq x \leq 1.1$) consisting of, e.g., a lithium transition metal complex oxide, among other things, $LiCoO_2$, $LiNiO_2$, $LiMn_2O_4$ or the like is preferably used. Such a lithium transition metal oxide can be obtained by the following method. That is, for example, a carbonate, nitrate, oxide, a hydroxide, and the like of Li, Co, Ni, and Mn are used as start materials, and these start materials are mixed with each other depending on a composition and burned in a temperature range of 600°C to 1,000°C.

[0033]

As the negative electrode active material of the negative electrode, a low crystalline carbon material obtained by burning a material in which, e.g., Li can be doped or undoped at a relatively low temperature of, e.g., 2,000°C or less, a high crystalline material such as artificial graphite or natural graphite obtained by treating a material which can be easily crystallized at a high temperature of about 3,000°C, or the like is used. For example, thermolysis carbons, cokes, graphites, glass-like carbons, organic high molecular compound burned materials (obtained by burning a furan resin or the like at an appropriate temperature and carbonated the resultant material), a carbon fiber, and an activated carbon can be used.

[0034]

As the low crystalline carbon material, a carbonaceous material which is obtained by burning a furan resin, a petroleum pitch, or the like at less than 1,500°C and carbonating the resultant material, in which a spacing of (002) surfaces obtained by a wide angle X-ray differential method is 3.70 Å or more and the degree of vacuum is less than 1.70 g/cm^3, and which does not have a heat generation peak of 700°C or more in a differential thermal analysis in an air current is preferably used. As a graphite powder, a carbonaceous material in which a spacing of (002) surfaces obtained by a wide angle X-ray differential method is less than 3.42 Å is preferably used. These carbonaceous materials are materials which have large amounts of doped and undoped Li and are excellent in charge/discharge cycle life performance. As a combination of the negative electrode material and the positive electrode material, a combination which is most appropriate to a device to be used can be selected.

[0035]

The separator can be constituted by a micro-porous film consisting of, e.g., polyethylene, polypropylene, or teflon.

[0036]

The nonaqueous electrolytic solution consists of an organic solvent and an electrolyte solved therein. A so-called polymer electrolyte obtained by mixing a nonaqueous electrolytic solution and a high molecular compound, or a polymer electrolyte

obtained by mixing or combining a high molecular compound with an electrolyte can also used.

As the organic solvent, for example, at least one organic solvent selected from a cyclic carbonate such as ethylene carbonate or propylene carbonate, a chain carbonate such as dimethyl carbonate or diethyl carbonate, a cyclic ester such as γ-butyrolactone or γ-valerolactone, a chain ester such as ethyl acetate or methyl propionate, and an ether such as tetrahydrofuran or 1,2-dimethoxyethane can be used.

As the electrolyte, a lithium which can be solved in a solvent to be used and has ionic conductivity, e.g., at least one selected from $LiPF_6$, $LiBF_4$, $LiClO_4$, $LiCF_3SO_3$, $LiN(CF_3SO_2)_2$, and $LiC(CF_3SO_2)_3$ can be used.

[0037]

A lid 7, a PTC element 3, and a safety valve 6 are caulked on one end side of the outer packaging can 1 through a gasket 8 to seal one end of the outer packaging can 1. More specifically, the lid 7 serving as a positive-side terminal leading portion consisting of, e.g., stainless steel, Ni, or Fe, the ring-like PTC element 3 having, e.g., positive temperature characteristics, and the safety valve 6 arranged inside the PTC element 3 and consisting of Al are caulked on the opening end of the outer packaging can 1 and sealed such that these members are pinched by the gasket 8.

[0038]

At the central portion of the safety valve 6, a projecting portion 6a projecting toward the electrode element 2 is formed. The projecting portion 6a is welded on a sub-disk 4 (to be described later) through a central hole 11c of a disk 11 (to be described later). In this manner, the projecting portion 6a is electrically connected to the sub-disk 4.

[0039]

The disk 11 is fixed to the inside of the safety valve 6 through a disk holder 12. This disk 11 is constituted by, e.g., a metal plate consisting of Al. The disk holder 12 has a function of electrically insulating the safety valve 6 and the disk 11 from each other.

[0040]

The shape of the disk 11 will be described here, FIG. 1B is a plan view of a disk used in the nonaqueous electrolyte secondary battery according to the embodiment.

The edge portion 11a of the disk 11 is a belt-shaped plate which partially constitutes the disk 11 and has a circular shape at the outside of the plate. The outer edge portion 11a itself is fixed to the gasket 8 to support the disk 11 as a whole.

[0041]

A peripheral portion 11f and a separate portion 11g partially constitute the disk 11, and are plates which are connected to each other through a thin portion 11e (to be

described later). The peripheral portion 11f and the separate portion 11g are connected to the edge portion 11a, and forms a recessed portion on the electrode element 2 side with respect to the edge portion 11a.

[0042]

The disk 11 has the central hole 11c. The central hole 11c is a circular hole centering the symmetrical point of the disk 11, and is formed on the separate portion 11g of the disk 11. The central hole 11c has a function of causing the projecting portion 6a of the safety valve 6 to pass the projecting portion 6a of the safety valve 6 therethrough.

[0043]

Peripheral holes 11d are formed at six positions across the peripheral portions 11f, the thin portions 11e, and the separate portion 11g. Each peripheral hole 11d is an almost rectangular hole having a semicircular portion on the central hole 11c side, and the central axis of the peripheral hole 11d is in the radial direction. The peripheral hole 11d has a function of causing a gas (to be described later) generated in the battery to pass.

[0044]

The disk 11 has the linear thin portion 11e. The thin portion 11e is almost along a circle centering on the symmetrical point of the central hole 11c. The thin portion 11e crosses the peripheral hole 11d.

[0045]

The position of the thin portion 11e is not limited to the position described above. More specifically, the thin portion 11e is preferably arranged outside the sub-disk 4 and in an inside region of the outermost periphery of the peripheral portion 11f. This is because when the thin portion 11e is arranged inside the sub-disk 4, the thin portion 11e cannot be sheared. In addition, when the thin portion 11e is arranged outside the outermost periphery of the peripheral portion 11f, the thin portion 11e cannot be sheared.

[0046]

The thin portion 11e itself may cross the peripheral hole 11d as described above, or may form a perfect circular shape which does not cross the peripheral hole. Furthermore, the thin portion 11e is not limited to the circular thin portion as described above. In short, the thin portion 11e may employ any shape in which the separate portion 11g can be separated from the peripheral portion 11f.

[0047]

The thickness of the thin portion 11e is 0.2 mm. In contrast to this, the thicknesses of the peripheral portion 11f and the separate portion 11g are 0.4 mm. In this case, as the thickness of the thin portion 11e, 0.2 mm is employed. However, the thickness of the thin portion 11e is not limited to the thickness of 0.2 mm. The thickness can be changed depending on

the value of pressure at which cleavage must be performed as a matter of course. In addition, not only the thickness of the thin portion 11e makes the thin portion entirely uniform, but also the thickness partially change the thin portion, so that portions wherein cleavage easily occurs can also be formed.

[0048]

The sub-disk 4 will be described below with reference to FIG. 1A. The sub-disk 4 has a thin-disk-like shape, and consists of a metal, e.g., Al. The sub-disk 4 is welded on the electrode element 2 of the disk 11 at the center of the disk 11.

The free end of the positive electrode lead 9 is welded on the surface of the sub-disk 4 on the electrode element 2 side. In this manner, the sub-disk 4 and the positive electrode lead 9 are electrically connected to each other. As a result, the projecting portion 6a of the safety valve 6 is electrically connected to the positive electrode lead 9.

[0049]

The operations of a safety valve and a disk used in the nonaqueous electrolyte secondary battery according to this embodiment will be described below. In this case, the safety valve has two mechanisms, i.e., a current cut-off mechanism and a cleavage mechanism. The disk has a cleavage mechanism.

[0050]

Before the current cut-off mechanism and the cleavage mechanism are described, a normal state of the safety valve will

be described. FIG. 2A is a sectional view showing a manner of the safety valve 6 and the disk 11 in the normal state in the conventional nonaqueous electrolyte secondary battery. FIG. 2A shows a top part of FIG. 1A.

[0051]

In FIG. 2A, although the sub-disk 4 closes the central hole 11c of the disk 11, the diameter of the sub-disk 4 is small. For this reason, the peripheral hole 11d formed near the outer periphery of the disk 11 is not closed by the sub-disk 4. Since the peripheral hole 11d is not closed as described above, a gas existing in the battery can pass through the disk 11. In contrast to this, since the safety valve 6 has no hole, the gas existing in the battery cannot be discharged outside, and an airtight state is kept. This state is a normal state in FIG. 2A.

[0052]

An operation in the current cut-off mechanism of the safety valve will be described below. FIG. 2B is a sectional view showing an action of the safety valve in a current cut-off state in the nonaqueous electrolyte secondary battery according to this embodiment.

[0053]

When gas is generated in the outer packaging can 1 on account of some causes, pressure therein increases. At this time the generated gas passes through the peripheral hole 11d

and applies pressure on the inside surface of the safety valve. As a result the safety valve is bulged to the outside and deformed. As a result of the deformation volume within the battery increases and lessens an internal pressure by the increase.

[0054]

Due to the deformation of the safety valve 6, in the welded portion between the projecting portion 6 of the safety valve 6 and the sub-disk 4, part of the sub-disk 4 that exists in the surroundings of the welded portion is ripped off by a shearing force. As a result of the projecting portion 6a and the sub-disk 4 parting from each other in this manner an electrical connection between the positive electrode lead 9 and the lid 7 is cut off. In other words, although the electrode lead 9 is electrically connected to the safety valve 6 throug the sub-disk 4 and the projecting portion 6a, and further through PTC element 3 and the lid 7, because of the sub-disk and the projecting portion 6a parting from each other as is mentioned above an electric connection between the positve electrode 9 and the lid 7 becomes to be cut off.

[0055]

A modification of the safety valve 6 will be described here in detail. As is apparent from FIG. 2B, when the safety valve 6 is transformed, the safety valve 6 is largely transformed at positions 6k and 6l. More specifically, the

portions are the position 6k which indicates the outermost periphery of the inner flat region of the safety valve 6 and the position 6l which is very close to the projecting portion 6a. Portions except for these portions, i.e., the projecting portion 6a is rarely transformed, and the flat portion outside a projecting portion 6s is slightly transformed.

[0056]

As is apparent from FIG. 2B, the distance between the bending points 6k and 6l is large. For this reason, by the transformation of the safety valve 6, the projecting portion 6a is largely separated from the sub-disk 4. In this manner, since the projecting portion 6a and the sub-disk 4 can be largely separated from each other, an advantage that a current cut-off operation can be reliably performed is achieved.

[0057]

An operation in the cleavage mechanism of the safety valve will be described below. FIG. 2C is a sectional view showing actions of the safety valve and the disk in a cleavage state in the nonaqueous electrolyte secondary battery according to this embodiment.

When a pressure in the outer packaging can 1 is higher than the pressure in the current, the safety valve 6 itself is cleaved.

In this manner, when the safety valve 6 is cleaved, but the disk 11 is not cleaved, a gas generated in the battery

passes through the peripheral holes 11d of the disk 11, passes through a cleaved portion 6b of the safety valve 6, and passes through a ventilation hole 7a of a lid 7 to be discharged outside.

[0058]

An operation in the cleavage mechanism of the disk will be described below with reference to FIG. 2C.

When a pressure is higher than a pressure at which the cleavage mechanism of the safety valve operates, the cleavage mechanism of the disk 11 operates. More specifically, the separate portion 11g of the disk 11 is separated from the disk 11. In this manner, the separate portion 11g is floated, and a cleaved portion 11h is formed around the separate portion 11g. As a result, a gas generated in the battery can pass through not only the peripheral holes 11d of the disk, but also the cleaved portion 11h of the disk 11 at the same time. In addition, the generated gas passes through the cleaved portion 6b of the safety valve 6 and passes through the ventilation hole 7a of the lid 7 to be discharged outside.

[0059]

A cleavage manner of the disk 11 will be described here with reference to FIG. 3. FIG. 3 is a plan view showing a manner of a disk used in the nonaqueous electrolyte secondary battery according to this embodiment in a cleavage state.

When a gas is generated in the battery, the gas passes

through the peripheral holes 11d of the disk 11 first. In addition, when the pressure of the gas increases, a high pressure acts on the surface of the separate portion 11g on the electrode element 2 side. When the high pressure acts as described above, large shearing force acts on the thin portion 11e of the disk 11. In this case, the thin portion 11e is mechanically weakest, the thin portion 11e is easily sheared by the shearing force. As a result, the separate portion 11g is separated from the disk 11 in the state shown in FIG. 3B. The cleaved portion 11h is formed at the position where the thin portion 11e has been removed around the separate portion 11g.

[0060]

In this manner, when the disk 11 is cleaved, a passage area for a gas in the cleavage state of the safety valve increases. In the description, although the disk is cleaved after the safety valve is cleaved, the present invention is not limited to this order. More specifically, depending on a generation state of the pressure in the battery, the disk may be cleaved simultaneously with the cleavage of the safety valve. Also in any state of these states, the cleavage mechanism of the disk effectively operates, a passage area for a gas can be increased. As a result, the gas can be discharged within a short time in the cleavage state of the safety valve.

[0061]

When the disk is cleaved, the separate portion of the

disk may be floated from the disk to be in contact with the safety valve and electrically connected to the safety valve. However, when the gas is discharged out of the battery, the battery itself is set in a state in which the battery cannot function as a battery. For this reason, the separate portion and the safety valve can be electrically connected to each other without any problem.

In the embodiment described above, a cylindrical nonaqueous electrolyte secondary battery has been described. However, the application range of the present invention is not limited to the cylindrical nonaqueous electrolyte secondary battery. More specifically, the present invention can be applied to another battery having a pressure releasing mechanism as a matter of course.

The present invention is not limited to the above embodiment, and can employ various configurations without departing from the spirit and scope of the present invention.

[0062]

[Effect of the Invention]

The present invention achieves the effects described below.

Since a disk has a linear thin portion, a gas can be discharged within a short time in a cleavage state of the safety valve.

[Brief Description of the Drawings]

[FIG. 1]

FIG. 1 includes a sectional view of a nonaqueous electrolyte secondary battery according to the present invention and a plan view of a disk used in the nonaqueous electrolyte secondary battery.

[FIG. 2]

FIG. 2 is a sectional view showing actions of a safety valve and a disk in a normal state, a current cut-off state, and a cleavage state in the nonaqueous electrolyte secondary battery according to the present invention.

[FIG. 3]

FIG. 3 is a plan view showing a manner of the disk used in the nonaqueous electrolyte secondary battery according to the present invention in a cleavage state.

[FIG. 4]

FIG. 4 includes a sectional view of a conventional nonaqueous electrolyte secondary battery and a plan view of a disk used in the nonaqueous electrolyte secondary battery.

[FIG. 5]

FIG. 5 is a sectional view showing an action of a safety valve in a normal state, a current cut-off state, and a cleavage state in the conventional nonaqueous electrolyte secondary battery.

[Description of reference numerals]

1 ... Outer packaging can; 2 ... Electrode element; 3 ... PTC element; 4 ... Sub-disk, 6 ... Safety valve; 6a ... Projecting portion; 6b ... Cleaved portion; 7 ... Lid; 7a ... Ventilation hole; 8 ... Gasket; 9 ... Positive electrode lead; 10 ... Negative electrode lead; 11 ... Disk; 11a ... Edge portion; 11b ... Recessed portion; 11c ... Central hole; 11d ... Peripheral hole; 11e ... Thin portion; 11f ... Peripheral portion; 11g ... Separate portion; 11h ... Cleaved portion; 12 ... Disk holder

[Name of Invention] ABSTRACT

[Summary]

[Problem] To provide a nonaqueous electrolyte secondary battery capable of discharging gas at a time of cleavage of a safety valve.

[Solving Means] An electrode element 2 is comprised of laminated films of a positive electrode, a negative electrode and a separator wrapped up around it. A lid 7, a PTC element 3, and a safety valve 6 are caulked on one end side of an outer packaging can 1 through a gasket 8 to seal one end of the outer packaging can 1. At the central portion of the safety valve 6, a projecting portion 6a is formed. The projecting portion 6a is welded onto a sub-disk 4 through a central hole 11c of a disk 11. The disk 11 is fixed to the inside of the safety valve 6 through a disk holder 12. Peripheral holes 11d of the disk 11 are formed at six spots ranging from a peripheral portion 11f, thin portion 11e to a separate portion 11g. The thin portion 11e is almost along a circle centering on the symmetrical point of the central hole 11c.

[Selected Figure] FIG. 1